Advanced Higher Physics
Astrophysics
Check Test 1: Solutions

Question			Expected response	Max mark	Additional guidance
1.	**a**		The (minimum) velocity/speed that a mass must have to escape the gravitational field (of a planet). **(1)**	**1**	Do not accept *escape gravitational force*. Accept: *escape gravitational well*, *velocity required to reach infinity*, *velocity required to give a total energy of* 0 J
	b		$E_k + E_p = 0$ **(1)** $\frac{1}{2}mv^2 - \frac{GMm}{r} = 0$ **(1)** $v^2 = \frac{2GM}{r}$ $v = \sqrt{\frac{2GM}{r}}$ **(1)**	**3**	$E_k = E_p$ award **0 marks** Start with $\frac{1}{2}mv^2 = \frac{GMm}{r}$ award **0 marks**
	c		$v = \sqrt{\frac{2GM}{r}}$ **(1)** $v = \sqrt{\frac{2 \times 6 \cdot 67 \times 10^{-11} \times 6 \cdot 0 \times 10^{24}}{1 \cdot 09 \times 10^{7}}}$ **(1)** $v = 8 \cdot 6 \times 10^{3}\ \mathrm{m\,s^{-1}}$ **(1)**	**3**	Accept: 9, 8·57, 8·569

2.	**a**	**i**	$\frac{GM_E m}{r^2} = m\omega^2 r$ $\omega = \frac{2\pi}{T}$ **(1)** $\frac{GM_E m}{r^2} = m\frac{4\pi^2}{T^2}r$ **(1)** $T = 2\pi\sqrt{\frac{r^3}{GM_g}}$	**2**	To access any marks candidates must start with equating the forces/ acceleration. A maximum of 1 mark if final equation is not shown.
	a	**ii**	$T = 2\pi\sqrt{\frac{(6\cdot4\times10^6 + 4\cdot0\times10^5)^3}{6\cdot67\times10^{-11}\times6\cdot0\times10^{24}}}$ **(1)** $= 5\cdot6\times10^3$ s **(1)**	**2**	Accept: 6 5·6 5·57 5·569
	b	**i**	Value from graph 4·15 × 10^5 (m) **(1)** $mg = \frac{GM_E m}{r^2}$ **(1)** $g = \frac{GM_E}{r^2}$ **(1)** $= \frac{6\cdot67\times10^{-11}\times6\cdot0\times10^{24}}{(4\cdot15\times10^5 + 6\cdot4\times10^6)^2}$ $= 8\cdot6\ \text{N kg}^{-1}$ **(1)**	**4**	Accept: 9 8·6 8·62 8·617
	b	**ii**	Less atmospheric drag/friction **or** will reduce running costs. **(1)**	**1**	

Question			Answer	Max mark	Additional guidance
3.	(a)	(i)	$F = \frac{mv^2}{r}$ 1 $24 \cdot 1 = \frac{1240 \times v^2}{(263 \times 10^3 + 680 \times 10^3)}$ 1 $v = 135 \text{ m s}^{-1}$	2	SHOW question $\frac{mv^2}{r} = \frac{GMm}{r^2}$ 1 $v = \sqrt{\frac{GM}{r}}$ $v = \sqrt{\frac{6 \cdot 67 \times 10^{-11} \times 2 \cdot 59 \times 10^{20}}{(263 + 680) \times 10^3}}$ 1 $v = 135 \text{ ms}^{-1}$ If final answer not shown a maximum of 1 mark can be awarded.
		(ii)	$v_c = \frac{2\pi r}{T}$ 1 $135 = \frac{2\pi(263 \times 10^3 + 680 \times 10^3)}{T}$ 1 $T = 4 \cdot 39 \times 10^4 \text{ s}$ 1 Accept: 4·4, 4·389, 4·3889	3	
	(b)	(i)	The work done in moving unit mass from infinity (to that point). 1	1	
		(ii)	$V_{low} - V_{high} = -3 \cdot 22 \times 10^4 - (-1 \cdot 29 \times 10^4)$ 1 $V_{low} - V_{high} = -1 \cdot 93 \times 10^4$ $(\Delta)E = (\Delta)Vm$ 1 $(\Delta)E = -1 \cdot 93 \times 10^4 \times 1240$ 1 $(\Delta)E = -2 \cdot 39 \times 10^7 \text{ J}$ 1 Accept: 2·4, 2·393, 2·3932	4	Can also be done by calculating potential energy in each orbit and subtracting. 1 for relationship 1 for all substitutions 1 for subtraction 1 for final answer including unit

4.			Demonstrates no understanding 0 marks Demonstrates limited understanding 1 marks Demonstrates reasonable understanding 2 marks Demonstrates good understanding 3 marks This is an open-ended question.	3	Open-ended question: a variety of physics arguments can be used to answer this question. Marks are awarded on the basis of whether the answer overall demonstrates “no”, “limited”, “reasonable” or “good” understanding.

Question			Answer	Max Mark	Additional Guidance
5.	(a)		$v = \sqrt{\frac{2GM}{r}}$ **1** $v = \sqrt{\frac{2 \times 6 \cdot 67 \times 10^{-11} \times 9 \cdot 5 \times 10^{12}}{2 \cdot 1 \times 10^{3}}}$ **1** $v = \sqrt{0 \cdot 603}$ $v = 0 \cdot 78\ (\text{m s}^{-1})$ **1** (lander returns to surface as) lander v less than escape velocity of comet **1**	4	
	(b)	(i)	SHOW QUESTION $(F_g = W)$ $\frac{GMm}{r^2} = mg$ **1** for both eqns, **1** for equating $g = \frac{GM}{r^2}$ $g = \frac{6 \cdot 67 \times 10^{-11} \times 9 \cdot 5 \times 10^{12}}{(2 \cdot 1 \times 10^{3})^2}$ **1** $g = 1 \cdot 4 \times 10^{-4}\ \text{N kg}^{-1}$	3	Show question, if final line is missing then a maximum of two marks. If the 2nd line is missing then 1 mark maximum for $F_g = W$ $\frac{F}{m} = \frac{GM}{r^2}$ or $g = \frac{GM}{r^2}$ As a starting point, zero marks
		(ii)	Height will be greater **1** Because 'a' reduces **1** with height **1**	3	'Must justify' question Alternative: Assumption that 'a' is constant is invalid 1 The value for 'a' is too large 1